Jet Propulsion Laboratory
California Institute of Technology

Harmonized SIF
(and Application in Atmospheric Inversion)

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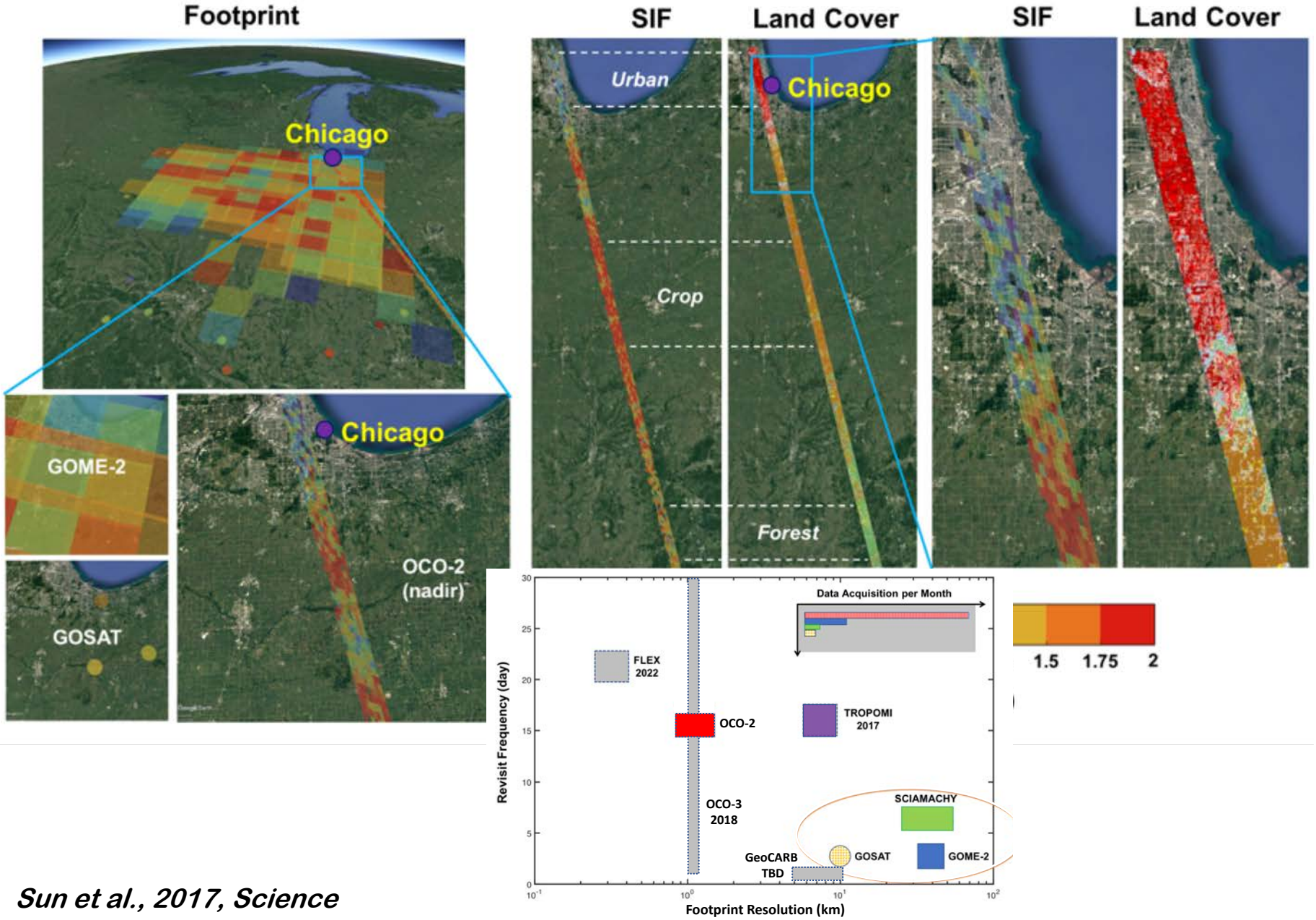
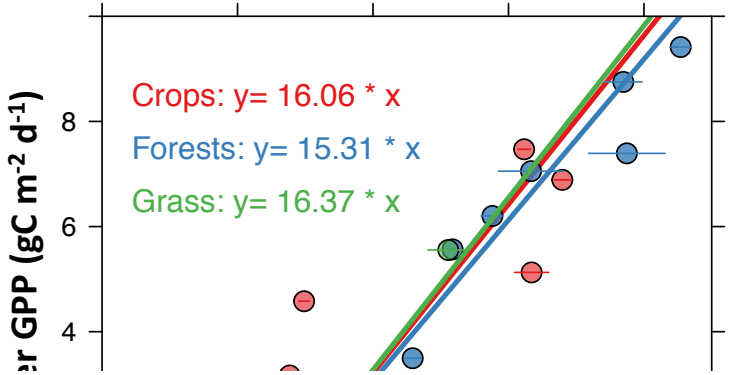
OCO-2 SIF tower-based photosynthesis observation



Sun et al., 2017, Science

OCO-2 SIF to Anchor Production of Longer Time Series



GOME: 1996 - 2011

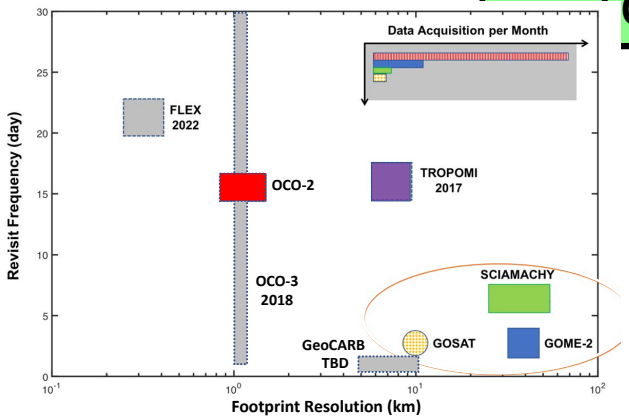
SCIAMACHY: 2002 - 2012

GOME-2: 2007 - present

GOSAT: 2009 - present

OCO-2: 2014 - present

TROPOMI



1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018 2020

Current SIF Record: 2002-2016

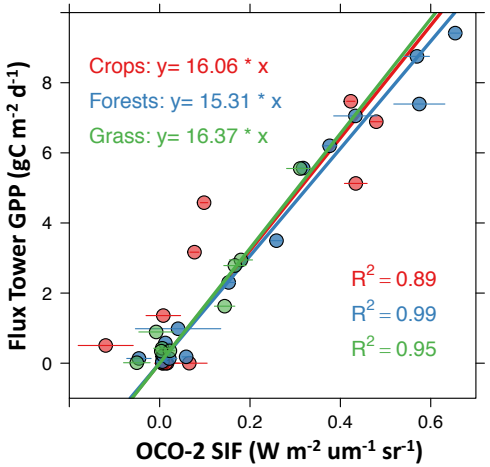
Proposed SIF Record: 1996-2020

NASA MEaSUREs 2017:

Multi-decadal Time Series of Vegetation Chlorophyll Fluorescence and Derived Gross Primary Production

Science Focus/Objectives

1. Create a 25 year (1996-2020) global observation-based SIF ESDR
2. Create a 25 year global GPP ESDR based on upscaled SIF
3. Deliver quantified uncertainties for SIF and GPP

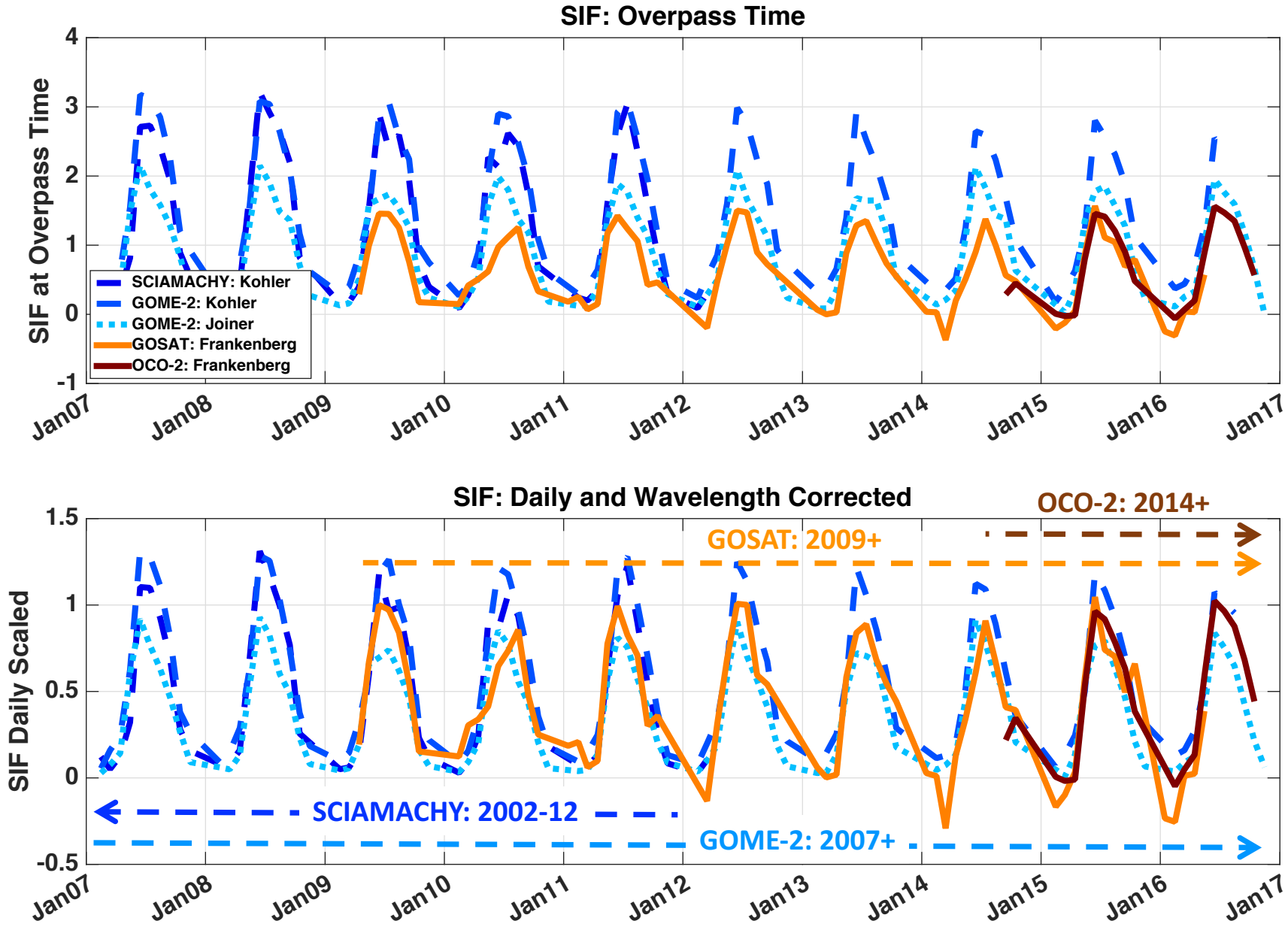


Approach to ESDR Development

1. **Orbital SIF (L2)**: Ongoing retrieval algorithm development for GOME-1/2, SCIAMACHY, GOSAT, OCO-2, and TROPOMI; *cross-sensor calibration anchored by OCO-2 cal/val to tower/airborne network*
2. **Enhanced SIF (L3)**: Data fusion methods (ML and Geostatistics) to merge calibrated SIF with ancillary veg and env data for global continuous and network targeted products
3. **Global GPP (L4)**: Upscaling of SIF to GPP using biome specific relationships at flux towers

Development and Delivery Schedule

1. **Orbital SIF**: Deliver prelim datasets based on current retrieval algorithms to ORNL DAAC sandbox by June 2019 (maybe by AGU). *Focus on consistency of format and variables across sensors*. Make publicly available via MEaSUREs website by June 2021. Update with algorithm development and sandbox feedback.
2. **Enhanced SIF**: First release by June 2020
3. **Global GPP**: First release by June 2021.


SIF: Overpass Time
SIF at Overpass Time
SCIAMACHY: Kohler
GOME-2: Kohler
GOME-2: Joiner
GOSAT: Frankenberg
OCO-2: Frankenberg
SIF: Daily and Wavelength Corrected
SIF Daily Scaled
OCO-2: 2014+
GOSAT: 2009+
SCIAMACHY: 2002-12
GOME-2: 2007+
Jan07
Jan08
Jan09
Jan10
Jan11
Jan12
Jan13
Jan14
Jan15
Jan16
Jan17

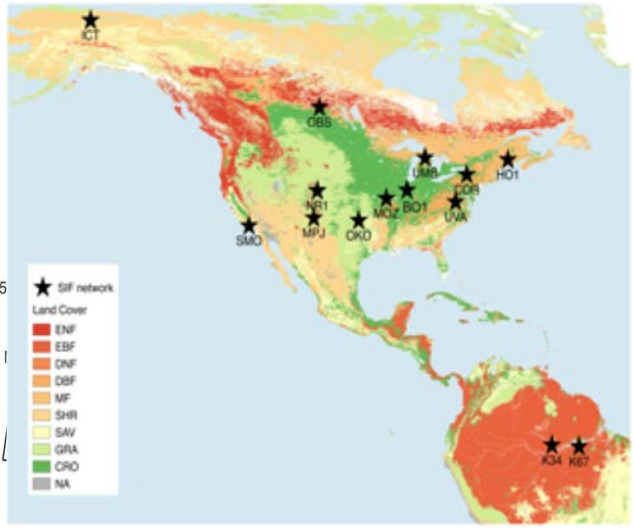
Science Value

- Combines independent SIF retrievals from multiple satellites into a harmonized, multi-decadal record of SIF and GPP spanning the period 1996-2020.
- Combination of multiple vegetation remote sensing measures provides the means to address outstanding science questions in the growing SIF community, including:
  - **What is the true temporally and spatially integrated SIF?**
  - **How valid is the linear theory of SIF to GPP?**
  - **What are the current rates and trends of global SIF and GPP?**

Development Approach

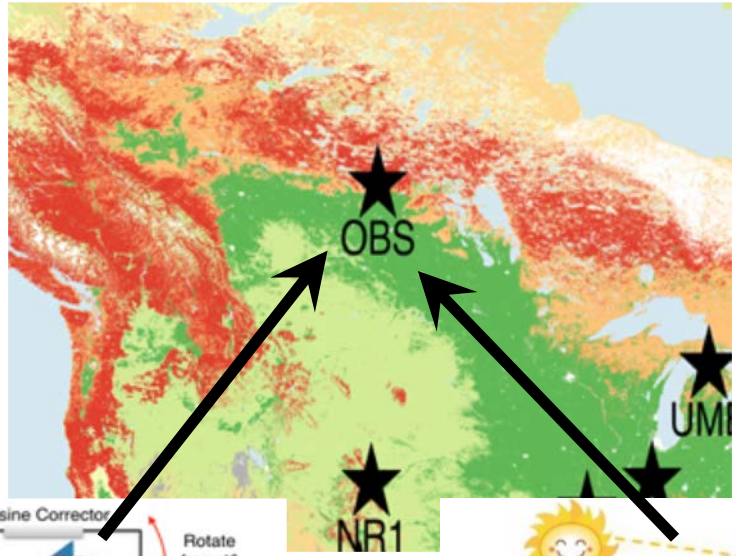
- Start from existing research-grade retrieval algorithms for each instrument
  - *Reformat existing products (GOME2, SCIAMACHY, GOSAT, OCO2, TROPOMI) and deliver to ORNL sandbox*
  - *Decide on common format, variables, corrections, and post-screening filters*
- Leverage small OCO-2 footprints to calibrate multi-year OCO-2 retrievals against canopy level measurements from tower and airborne sensors.
- Match OCO-2 overpasses to tower/airborne data using target mode collection and machine learning (network targeted sif)
- Cross-calibrate retrieval algorithms for other sensors against OCO-2, anchoring production of back-calibrated time series
  - *Ensure that same L1 radiances are used for multiple products derived from same sensor*
- Use data fusion to map MODIS veg reflectance and MERRA-2 environmental reanalysis into harmonized SIF for global and network target SIF products
- Analyze network targeted SIF against tower GPP measurements to establish biome dependent SIF/GPP relationships
- Combine tower relationships with global calibrated SIF for global upscaled GPP

SIF Tower Network



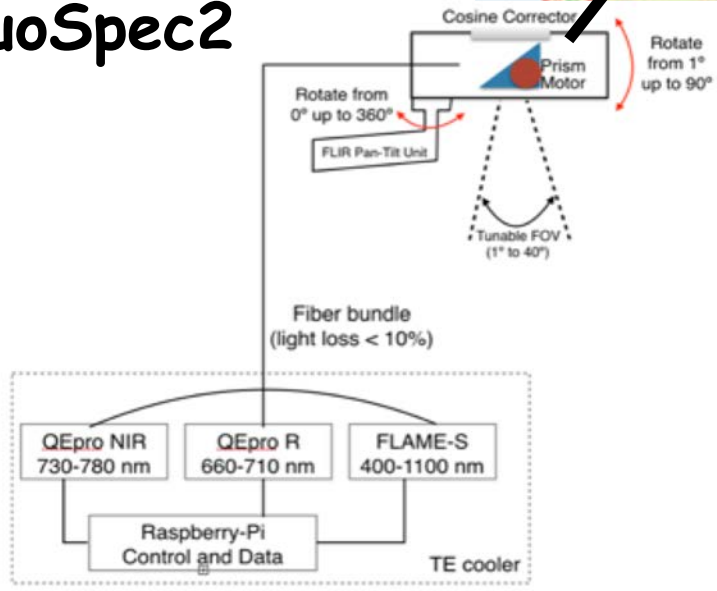
Twitter.com/Photo_spec

Intercomparison of FluoSpec & PhotoSpec: Old Black Spruce, Spring 2018

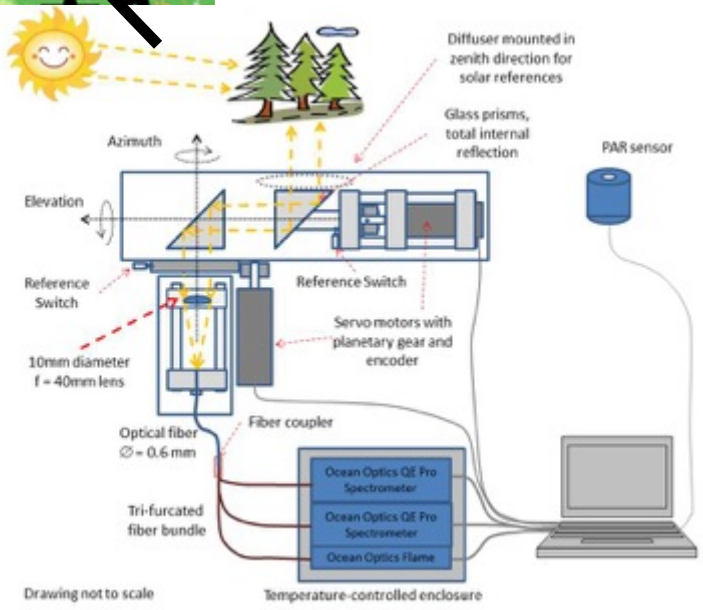


PhotoSpec will scan field of view of FluoSpec2 to determine leaf-to-canopy scaling

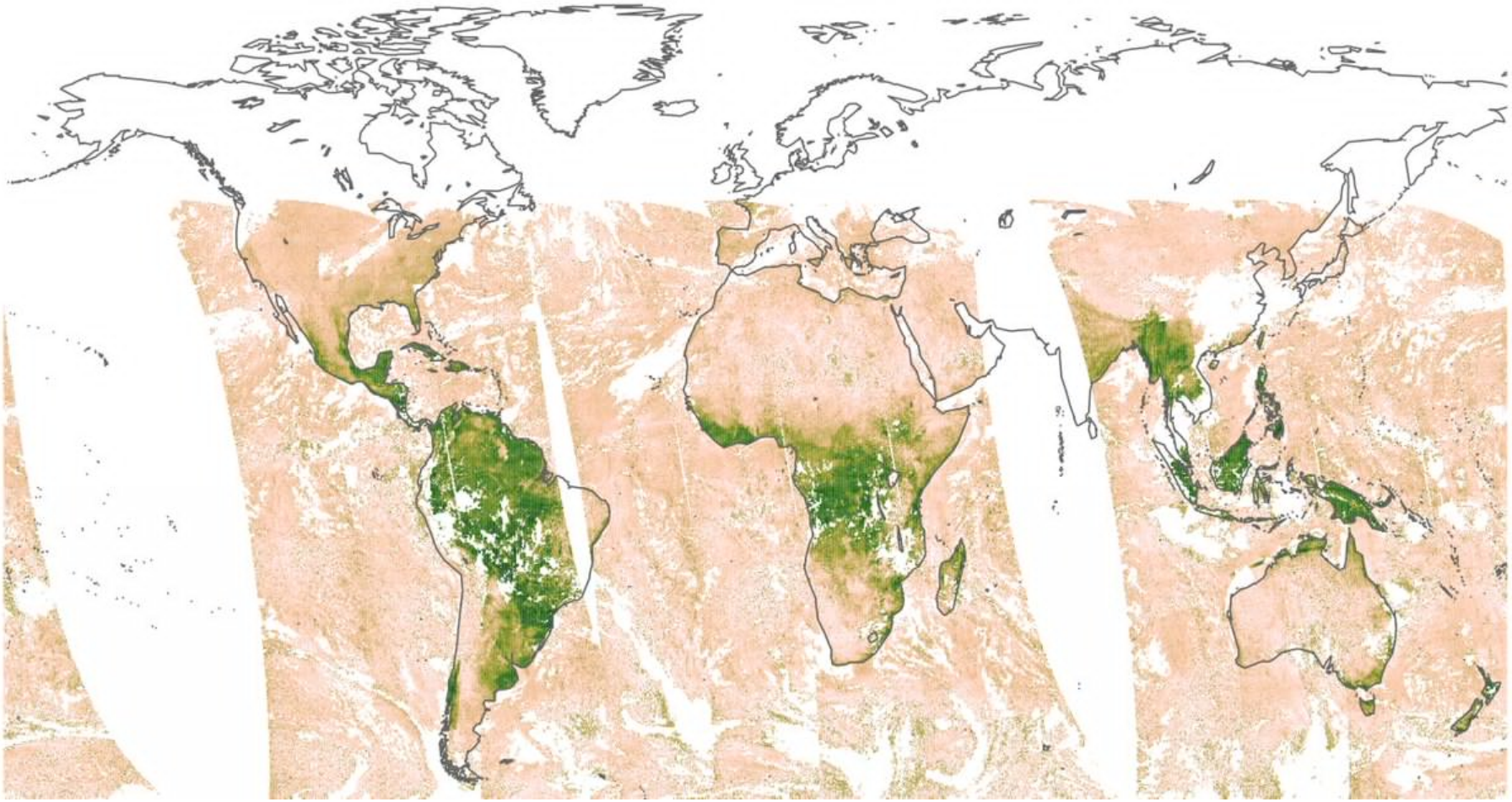
FluoSpec2



PhotoSpec



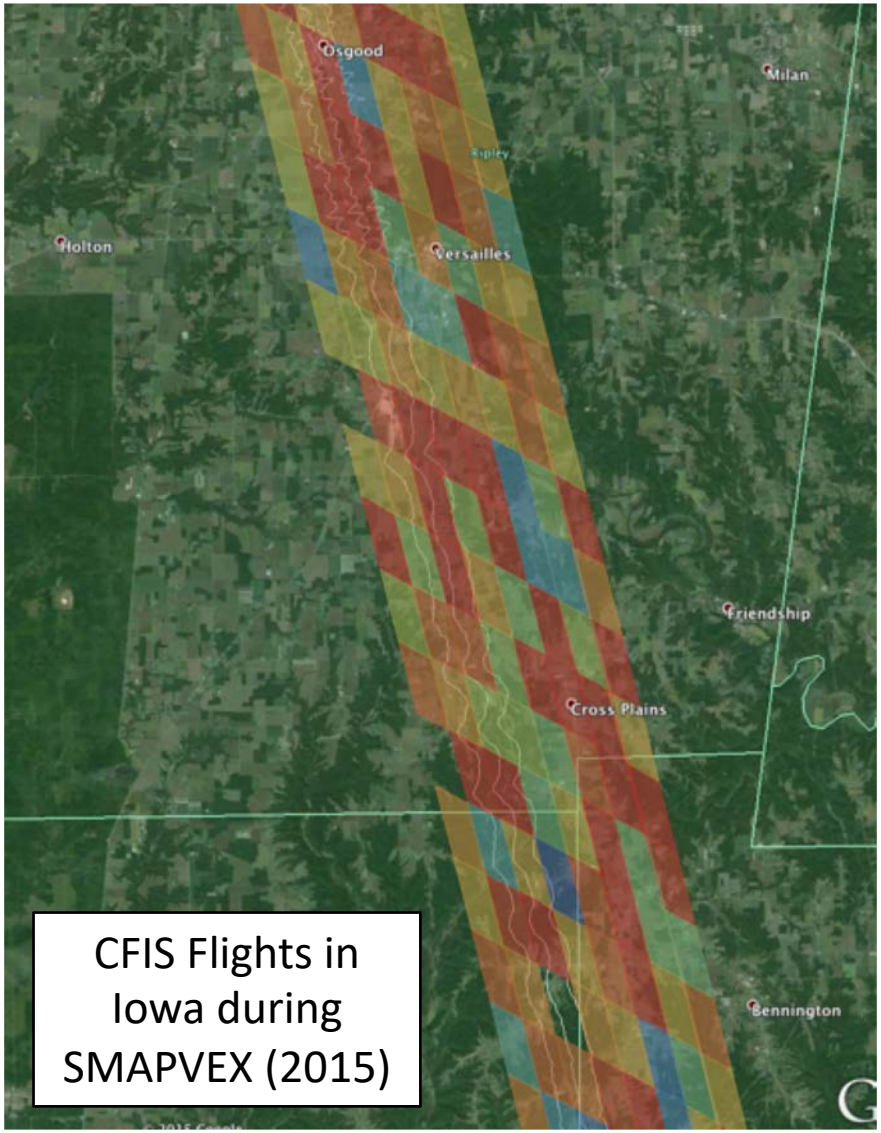
Daily global snapshot from TROPOMI



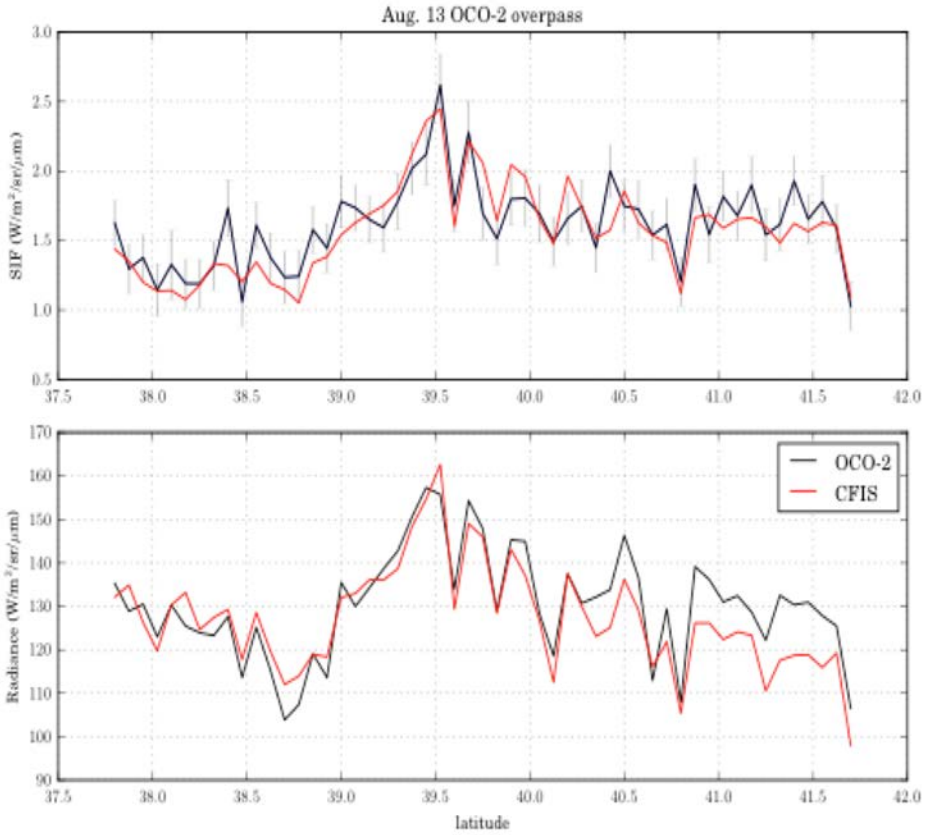
Nov 29, 2017

Courtesy Christian Frankenberg and Philipp Kohler, Caltech

CFIS flights within OCO-2 Field of View



CFIS Flights in Iowa during SMAPVEX (2015)



Sun and Frankenberg et al., Science, 2017

ABoVE CFIS flights: 2017

OCO-2 Targets: April 2018

N34.25°
N34.15°
Pasadena
Glendale
Los Angeles
N34.05°
El Monte
West Covina
Whittier
W118.3°
W118.1°
W117.9°
N33.95°
Downey
Norwalk
Compton
Buena Park
Fullerton
Redondo Beach
N33.85°
Torrance
Carson
Long Beach
© 2018 Google
Image Landsat / Copernicus
Data USGS
Imagery Date: 12/3/2017 lat 33.972304° lon -118.174136° elev 40 m eye alt 40.63

Data Fusion of MODIS FPAR and Calibrated SIF

Global, Continuous, Gap-Filled SIF

- Gap filling
- High spatial resolution
- Reduced uncertainty in well observed regions and along satellite tracks

MODIS FPAR
- **Footprint: 1 km2**
- **Spatial Res: 1 km**

+

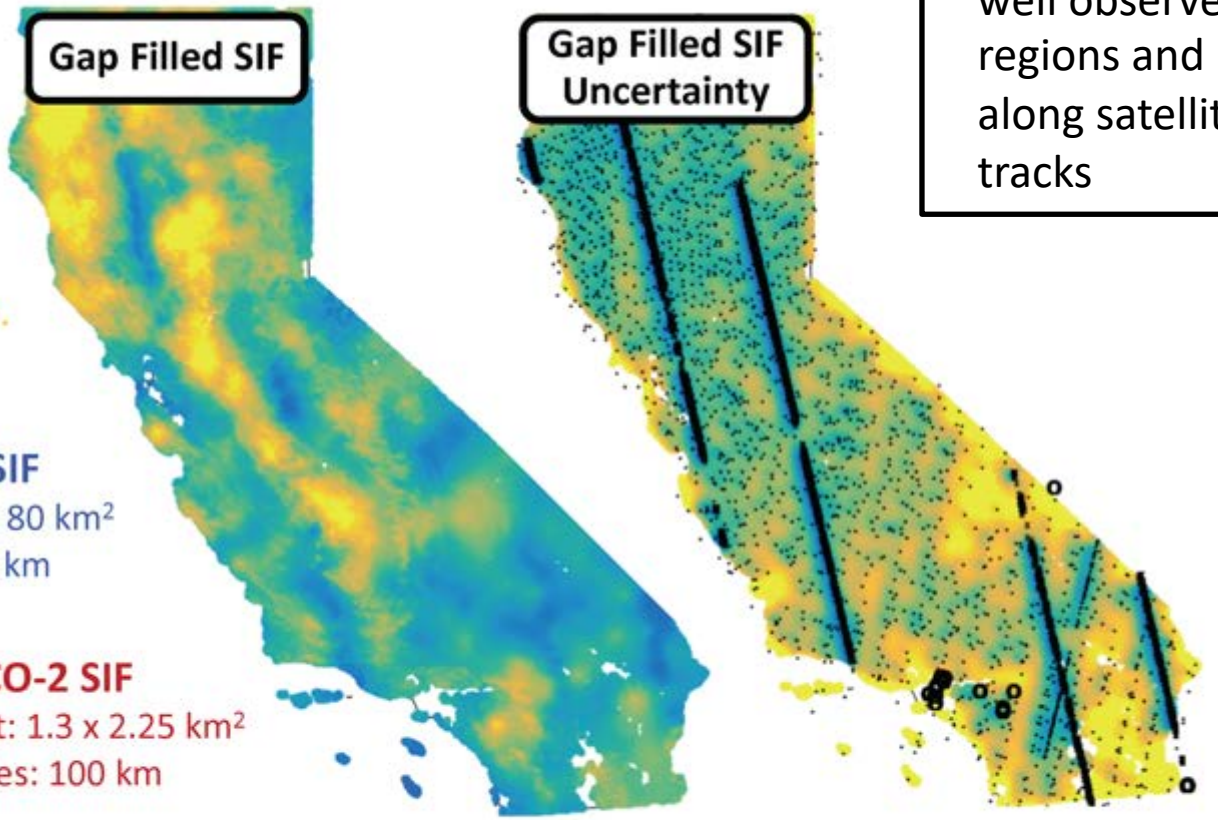
GOSAT SIF
- Footprint: 10 km diam.
- Spatial Res: 100 km

+

GOME-2 SIF
- Footprint: 40 x 80 km^2
- Spatial Res: 50 km

+

OCO-2 SIF
- Footprint: 1.3 x 2.25 km^2
- Spatial Res: 100 km



= **Gap Filled SIF + Uncertainty**
- Spatial Res: 5 km

Acknowledgements

- A portion of this research was performed for a MEaSUREs 2017 investigation (NNH17ZDA001N), under contract with NASA.